REMARKS

Claims 1-4, 6, and 8-12 are pending in the application, with claims 1-4, 6, 8, 9, and 11 being currently amended, and claim 12 being newly added.

Independent claims 1 and 2 have been amended to more clearly define the invention over the art of record. In particular, claims 1 and 2 now specify that the primary surface of the second semiconductor layer faces the interface between the first semiconductor layer and the second semiconductor layer, and the side surface of the first concave portion is inclined against the interface. In addition, independent claims 1 and 2 no longer recite the phrase "that faces the interface between the first semiconductor layer and the second semiconductor layer". And claim 2 further recites that the first electrode is also formed on the primary surface of the second semiconductor layer surrounding the first concave portion, and forms a Schottky junction to the semiconductor layers which contact therewith.

Independent claim 3 has been amended to further recite that the primary surface of the second semiconductor layer faces the first interface between the first semiconductor layer and the second semiconductor layer, and the side surface of the first concave portion is inclined against a second interface between the first semiconductor layer and the third semiconductor layer. Claim 3 also no longer recites the phrase "that faces the interface between the third semiconductor layer and the second semiconductor layer".

The dependencies of dependent claims 4, 6, 8, 9, and 11 have been appropriately amended.

Claim 11 has also been further amended to recite that a forward current passes from the first electrode to the second electrode when a voltage is applied from the first electrode to the second electrode, and a reverse current passing from the second electrode to the first electrode is restricted when the voltage is applied from the first electrode to the second electrode.

Finally, new claim 12 has been added which further requires that an inclination angle of the side surface of the first concave portion be equal to or greater than 10 degrees, and smaller than 90 degrees.

Support for the amendments and new claim 12 can be found throughout the specification. No new matter has been added.

Response to Claim Objections

In the Official Action, claim 3 is objected to because there allegedly is insufficient antecedent basis for the limitation "the interface". Official Action at Paragraph 4. Applicants have respectfully amended this claim, as discussed above, to overcome the objection.

Also, claims 4 and 11 are objected to as being in improper form because a multiple dependent claim should refer to other claims in the alternative. Official Action at Paragraph 5. Applicants have respectfully amended these claims, as discussed above, to overcome the objection. Dependent claims 6, 8, and 9 have been similarly amended.

Finally, claim 11 is further objected to because there is allegedly insufficient antecedent basis for the limitation "the forward current" in the claim. Official Action at Paragraph 6. Applicants have also respectfully amended the claim, as discussed above, to overcome the objection.

Accordingly, the above objections are overcome and must be withdrawn.

35 U.S.C. §112, 2nd Paragraph -- Rejection of Claims 1-4, 6, and 8-11

In the Official action, previously pending claims 1-4, 6, and 8-11 stand rejected under 35 U.S.C. §112, second paragraph, as being indefinite. Official Action at Paragraph 7.

In rejecting independent claims 1-3, Examiner states that is unclear from the disclosure how the concave portion faces the interface, what surface faces the interface, or how

the concave portion may face the interface even as it extends deeper than the interface. And, regarding claim 11, Examiner states that this claim is in marked contrast to Applicant's specification at page 10, line 16 to page 11, line 17.

In view of the rejections, independent claims 1-3, as well as dependent claim 11, have been amended, as is discussed above, to more clearly define Applicants' invention. As a result, Applicants submit that the §112 rejections are overcome and must be withdrawn.

35 U.S.C. §102 -- Rejections of Claims 1, 2, and 10

In the Official Action, previously pending claims 3 and 11 stand rejected under 35 U.S.C. §102(b) as being anticipated by Peatman et al. ("A Novel Schottky/2-DEG Diode for Millimeter- and Submillimeter-Wave Multiplier Applications" ("Peatman"). Official Action at Paragraph 8. Applicants respectfully disagree.

It is well established that "a claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). For the following reasons, Peatman clearly fails to teach each and every element of Applicants' semi-conductor device as recited in independent claim 3.

Specifically concerning independent claim 3, while Peatman appears to disclose a semiconductor device (Fig. 1) that includes a first, second, and third semiconductor layer with the third layer sandwiched between the first and second layer (*See* page 12, col. 1, lines 32-48), this reference does not at all teach (or suggest) that the third semiconductor layer is formed having a thickness that allows a quantum mechanical tunnel effect to be obtained, as required by independent claim 3. And while Peatman appears to disclose a first concave portion penetrating at least the second semiconductor layer from a primary surface of the second layer, Peatman further simply fails to teach (or suggest) that a side surface of the first concave portion is inclined

against a second interface between the first semiconductor layer and the third semiconductor layer, as now required by claim 3.

To that end, it is worth noting that an advantageous effect of the present invention, that is, an improved reduced forward voltage and reversed voltage resistance of the semiconductor device (See Fig. 2), is achieved by the new limitation "a side surface of the first concave portion is inclined against a second interface between the first semiconductor layer and the third semiconductor layer". *See, e.g.*, Fig. 8, where the inclined angle α of the side surface 31b of the first concave portion 31 is shown. Furthermore, since the side surface 31b of the first concave portion 31 is inclined against the interface 203 between the first semiconductor layer 13 and the third semiconductor layer 17, the layer thickness of the second semiconductor layer 14 at the area below the side surface 31b of the first concave portion 31 is relatively thin. For this reason, the lattice strain of the second semiconductor layer 14 is relaxed so as to reduce a piezo-polarization effect. As a result, the sheet density of the two-dimensional carrier 102 decreases, and hence, the area below the side surface 31b of the first concave portion 31 becomes easily depleted. Accordingly, when a voltage is applied in the inverse direction (for example, when a negative charge is applied to the first electrode 15 and a positive charge is applied to the second electrode 16), the depletion layer 104 can widely expand below the first electrode 15, as shown in Fig. 4, so as to enhance the reverse voltage resistance.

On the other hand, since the layer thickness of the second semiconductor layer 14 at the other area below the side surface 31b of the first concave portion 31 is relatively thick due to the inclined angle α of the side surface 31b of the first concave portion 31, the second semiconductor layer 14 is still strained so as to maintain the piezo-polarization effect. As a result, the sheet density of the two-dimensional carrier 102 does not decrease, and hence, a series resistance between the first electrode 15 and the second electrode 16 is reduced. Accordingly, when the voltage is applied in the forward direction (for example, when the positive charge is

applied to the first electrode 15 and the negative charge is applied to the second electrode 16), the forward (turn-on) voltage can be reduce.

In view of all of the above, Peatman does not at all teach (or suggest) the configuration of Applicants' semiconductor device as recited in independent claim 3, or any of its dependent claims. Accordingly, the anticipation rejections based on Peatman must be withdrawn.

35 U.S.C. §103 -- Rejections of Claims 1, 2, and 8-11

In the Official Action, previously pending claims 1, 2, and 8-11 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Peatman in view of Kanazawa (JP Application Publication 03-016179) ("the '179 publication"). *See* Official Action, Paragraphs 9 and 12. Applicants respectfully disagree.

To establish *prima facie* obviousness of a claimed invention, it is certainly well established that all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974). In the instant case, Applicants respectfully submit that the Examiner has failed to establish a *prima facie* case of obviousness for the reasons that follow. Thus, the rejection of claims 1, 2, and 8-11 must be withdrawn.

Independent claims 1 and 2 now require that the side surface of the first concave portion is inclined against the interface. In addition, independent claim 2 further requires that the first electrode is formed on the primary surface of the second semiconductor layer surrounding the first concave portion.

Peatman has been discussed above. Those same arguments apply equally with respect to this rejection.

Concerning Fukuzawa, like Peatman, this reference simply does not at all teach (or suggest) that a side surface of the first concave portion is inclined against the interface, as now required by independent claims 1 and 2. In addition, the advantageous effect of the present

invention, that is, an improved reduced forward voltage and reversed voltage resistance of the semiconductor device (See Fig. 2), is achieved by the new limitation "a side surface of the first concave portion is inclined against the interface". *See, e.g.*, Fig. 1, where the inclined angle α of the side surface 31b of the first concave portion 31 is shown. And, this is not at all obvious over the combination of Peatman and Kanazawa.

For the above reasons, the combination of Peatman and Kanazawa fails to render obvious the semiconductor device of independent claims 1 and 2, as well as their dependent claims.

Finally, claims 4 and 6 stand rejected under 35 U.S.C. §103(a) as being unpatentable either over Peatman in view Patel et al. (UK Patent Application Publication 2 279 806) ("the '806 publication") or over Peatman in view of the '179 publication, and further in view of the '806 publication. *See* Official Action, Paragraphs 10 and 11. Claims 4 and 6 depend from any one of independent claims 1 to 3. Therefore, Applicants submit that the Examiner's rejection of dependent claims 4 and 6 is in error for at least the same reasons discussed above with respect to claims 1 to 3.

No Prima Facie Case

For all of the above reasons, it is submitted that the claims as pending are patentable over the cited references, and that no prima facie case of obviousness was made before, nor would be applicable here over that same art. In that regard, the additional art cited by Examiner as being of interest is submitted not to change the situation.

Conclusion

As a result of the remarks given herein, Applicants submit that the rejections of the pending claims have been overcome. Therefore, Applicants respectfully submit that this case is in

condition for allowance and requests allowance of the pending claims.

If Examiner believes any detailed language of the claims requires further discussion, Examiner is respectfully asked to telephone the undersigned attorney so that the matter may be promptly resolved. Applicants also have submitted all fees believed to be necessary herewith. Should any additional fees or surcharges be deemed necessary, Examiner has authorization to charge fees or credit any overpayment to Deposit Account No. 23-3000.

Respectfully submitted,
WOOD, HERRON & EVANS, L.L.P.

By /Randall S. Jackson, Jr./
Randall S. Jackson, Jr.
Reg. 48,248

2700 Carew Tower
Cincinnati, Ohio 45202
(513) 241-2324
FAX (513) 241-6234